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RECENT PROGRESS IN THE USE OF HOLOGRAPHIC GRATINGS AND SEVERAL OF THEIR APPLICATIONS

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16. Abstract

An experimental study guided by theoretical considerations were performed to increase the efficiency of holographic gratings.

It was possible to achieve an efficiency of 33% using a grating with 3,600 lines with the Ly α line.

In addition, flat gratings with 6,000 lines per mm and concave gratings 300 mm in diameter with 1,200 lines per mm were made.

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G. Pieuchard and J. Flamand[1]

Efficiency of Holographic Gratings

Numerous tests performed on various types of holographic gratings have convinced us that one of the fundamental parameters to which efficiency is linked is the degree of modulation.

We were guided in our experimental work by the following classical results:

One can demonstrate that in the case when the phenomenon of diffraction is highly scalar – i.e., $\lambda \ll a$, λ being the wavelength in question and a being the spacing, this phenomenon is quite correctly described by the operation of the Fourier transform. The diffracted efficiency in the n order for a sinusoidal grating with modulation e illuminated by wavelength λ is given by

$$\mathcal{E} = \left[J_n (\varphi) \right]^2$$

with J_n = the Bessel function of the n-th order

$$\varphi = \frac{2\pi e}{\lambda}$$

One can thus calculate the modulations e corresponding to the following optimizations:

Order 1	$e = 0.276\ \lambda$	$\mathcal{E} = 33\%$
2	$e = 0.478\ \lambda$	$\mathcal{E} = 23\%$
3	$e = 0.67\ \lambda$	$\mathcal{E} = 18\%$

Likewise, canceling the zero order would lead to $e = 0.382\ \lambda$

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[1]Jouan-Quetin Jobin-Yvon - Longjumeau (91).

This theory may be considered to be equivalent for gratings with sinusoidal profiles to the theory which is called "scalar" for diffraction in the case of gratings with a triangular profile.

However, two important reservations must be formulated:

a) by expansion of the result obtained theoretically by Petit and experimentally by ourselves in the range of diffraction of engraved gratings, it appears that this scalar theory is only valid if $\lambda/a < 0.3$ or rather $\lambda/a < 0.1$;

b) on the other hand, we know that the profile of the grooves in the holographic gratings is not actually sinusoidal.

Experimental Results Obtained in the Scalar Range

We devoted particular attention in our study to gratings that operate at 1,216 Å.

In this case, theory predicts an efficiency of 33% for a modulation degree of 340 Å.

Grating: 3,600 lines	Order	(0	2%	
a = 2,500 Å		)1	31%	Ru 75%
		(2	4%	
2,400 lines	Order	(0	7%	
		)1	17%	Ru 60%
		(2	6%	
1,200 lines	Order	(0	3%	
		)1	18%	
		(2	4%	

If the corrections for the reflectivity are made, the result is very close to theoretical. It should be pointed out, however, that only the 3,600-line gratings give the correct reflectivity.

In order to study in a more satisfactory fashion the efficiency of holographic gratings, especially in areas where λ/a is greater than 0.2 or 0.3, it is necessary to be more familiar with the profiles.

By means of electron microscopy we have been able to obtain the probable profile of the 1,200 line-grating, confirmed by light microscopy on the basis of gratings with smaller numbers of lines.

Figure 1. Profile of Holographic Gratings.

I must mention that R. Petit et al. are studying theoretically the efficiency of holographic gratings by using this type of profile.

The first theoretical results are in good agreement with the experimental results. (They will be published in Optics Communication).

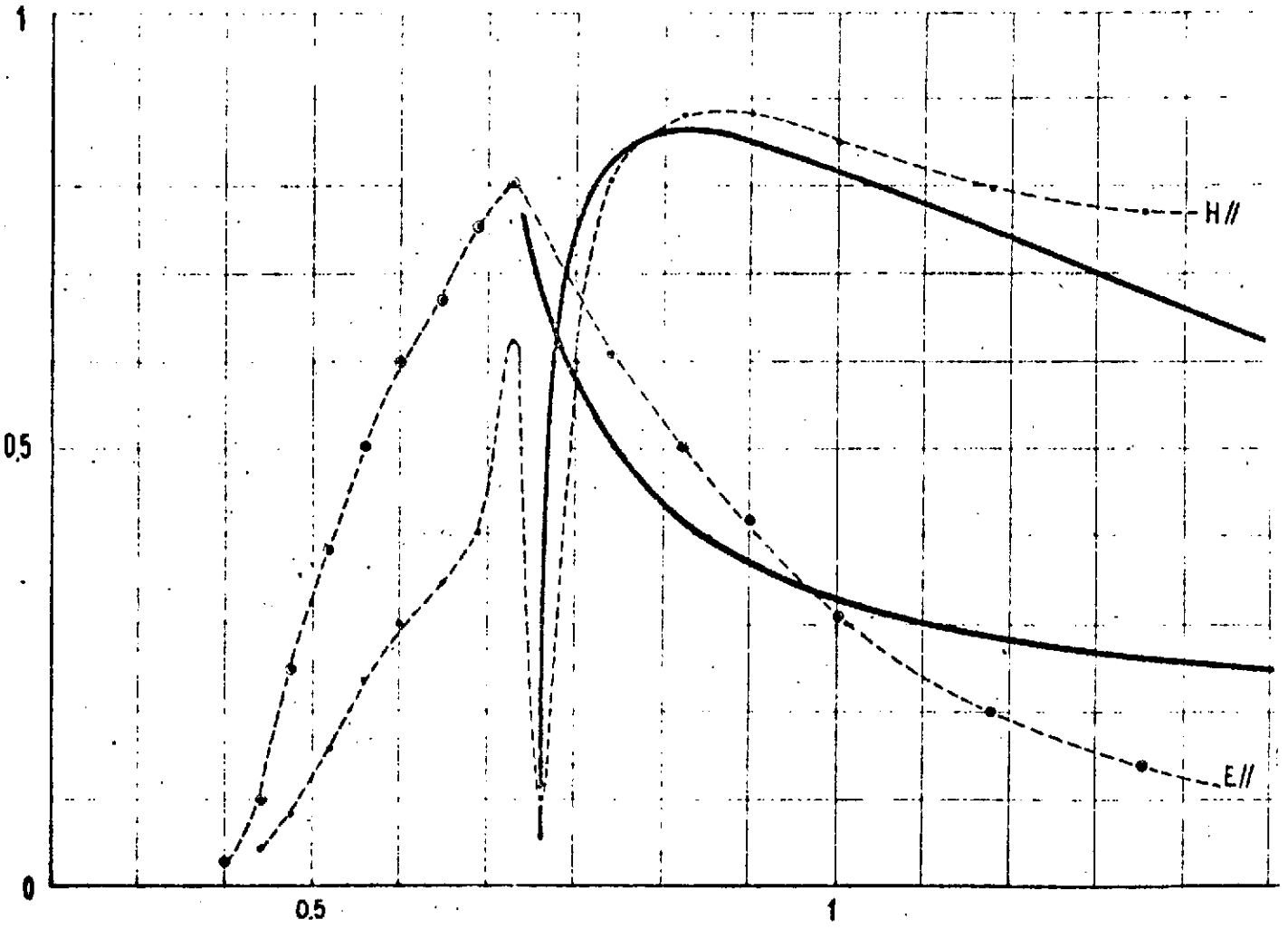

Figure 2. Comparison of Theoretical and Experimental Results.

Technological Results

A number of technological studies have recently been completed:

a) Manufacture of gratings with a small number of lines.

We have made holographic gratings with up to 300 lines per mm. The efficiency of these gratings is on the order of 30-40%.

b) Grating with a large number of lines.

We have made several gratings with 6,000 lines (120 × 200 mm). The efficiency is 32% at 2,500 Å. The resolution is currently being tested.

c) Large concave grating.

A grating 300 mm in diameter with 1,200 lines per mm (stigmatic) has been recorded.

Its resolution is 300,000 in the first order and 600,000 in the second order.

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